Automotive

Given a likely tripling in global car ownership by 2050, new consumption based approaches are required to tackle climate change by achieving a reduction in life-cycle emissions per vehicle by 85% by 2035. The globally integrated supply chains that support car consumption offer insights into the sources of global emissions from the auto sector, and opportunities for further emissions mitigation.

Key facts

- **Significant global emissions**
  Operation of the world's 700 million vehicles, together with vehicle manufacturing, contributes around 5%-6% of global GHG emissions.

- **An expanding, changing market**
  The production and sales of passenger vehicles is forecast to grow in all regional markets over the next two decades, with hybrid and electric vehicles becoming increasingly common.

- **Significant global flows**
  About 40% of emissions associated with vehicle manufacture move across an international border between production and consumption (sale) of the vehicle. Embodied emissions pathways between countries around the world drive significant differences between production and consumption emissions in the auto sectors of many countries.

- **The UK automotive sector**
  Automotive consumption in the UK drives more emissions production outside of the UK than domestically (excluding "tail pipe" emissions).

- **The importance of a life cycle perspective**
  Life cycle emissions per car are projected to fall by around 50% in the medium term due to technology innovation. Embodied emissions, rather than tail pipe emissions, will become the dominant source of life cycle emissions for new cars in only 5-10 years.

Implications for business

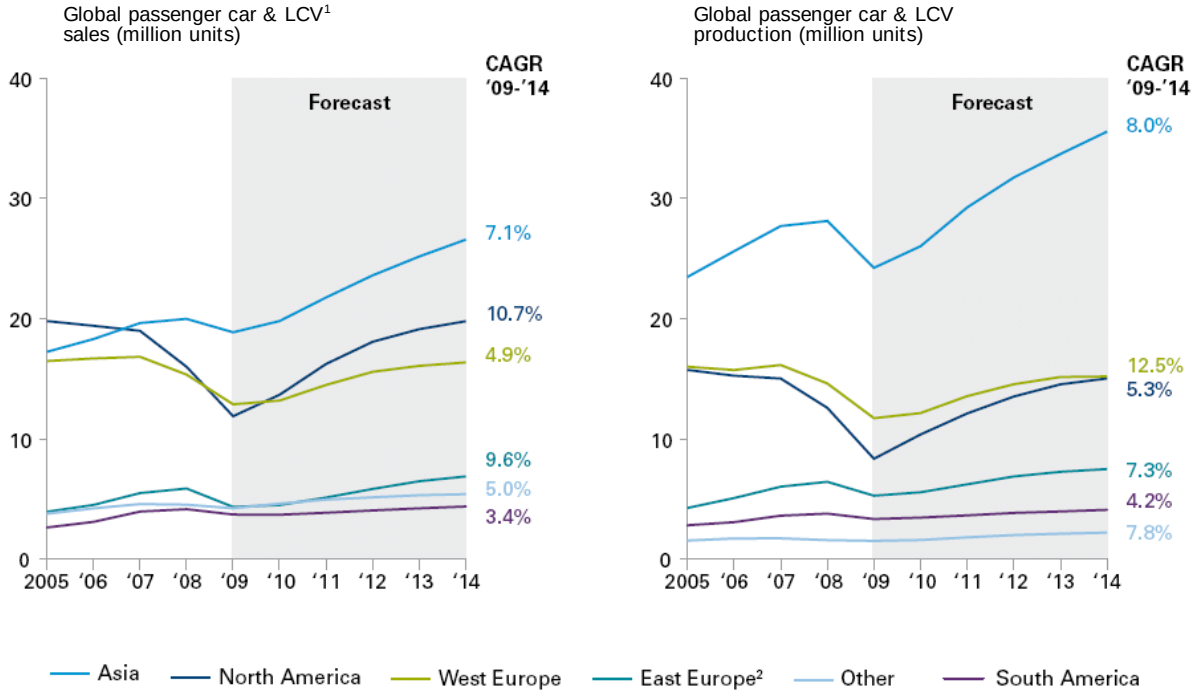
Importance of product carbon footprinting
The anticipated change in emphasis of automotive life cycle emissions – with embodied emissions forecast to increase in relative importance over the next decade – highlights the role that supply chain carbon emissions assessment and mitigation can play in this sector. The large-scale roll-out of product carbon footprinting to automotive vehicles could incentivise significant reductions in the embodied carbon in vehicles. Product carbon footprinting is particularly appropriate for two reasons.

- The trade-offs between embodied and in-use emissions require a life cycle approach to carbon measurement and management;

- Product carbon footprinting is very useful for understanding the emissions profile of complex international supply chains like those in the automotive sector. This enables better measurement, identification of carbon reduction opportunities for business, and clear communication of footprint and reduction efforts to harness consumer demand for low carbon products.

Global passenger vehicle sales are forecast to grow in all major global markets

Automotive sales (left) and production (right) by region



[1] Light commercial vehicles.

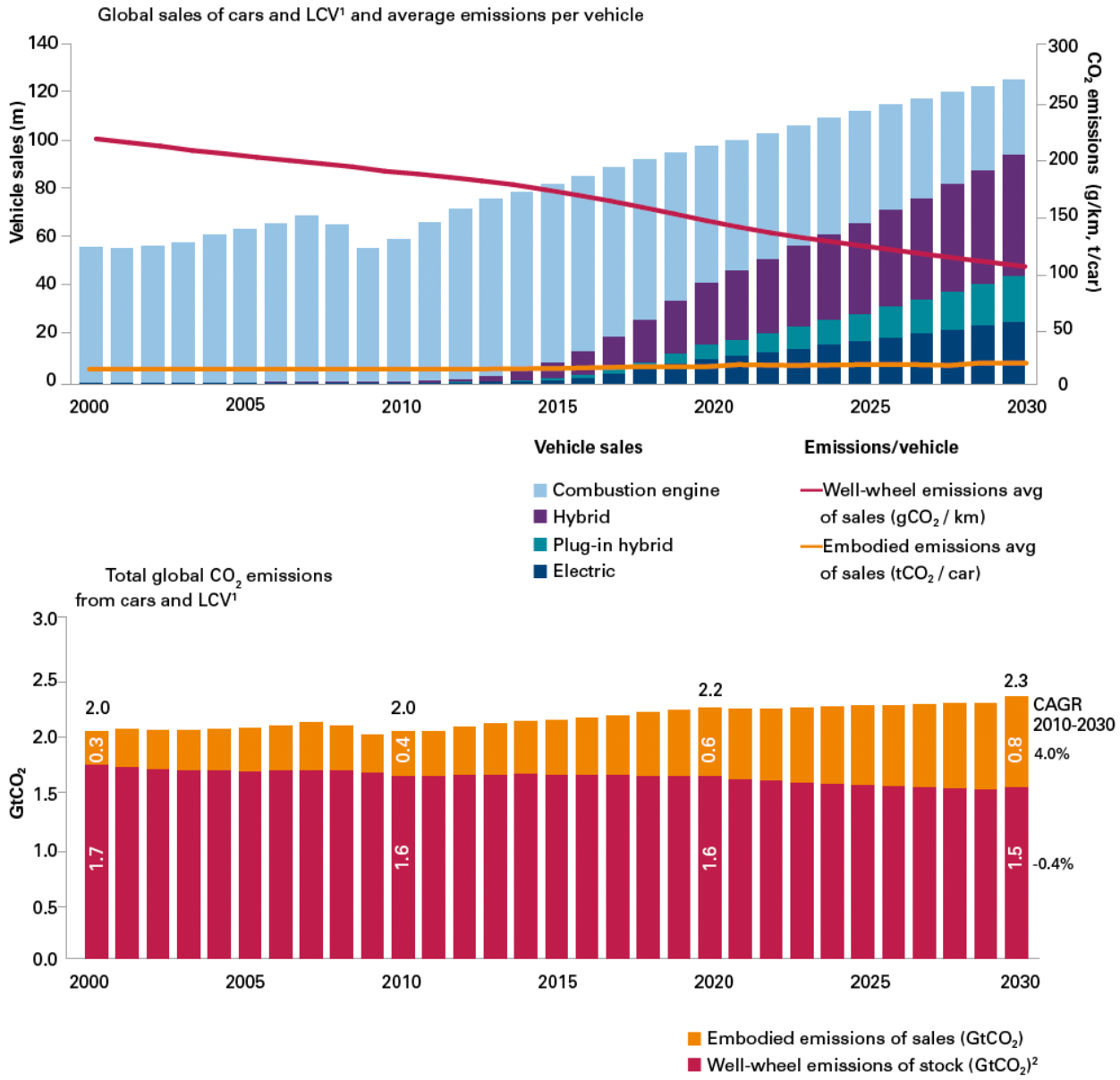
[2] East European EU countries plus Turkey, Serbia, Croatia, Russia and other CIS countries.

Source: Global Insight; BCG Analysis.

Sixty-nine million cars and light commercial vehicles were sold globally in 2007, with sales primarily occurring within three major regions: 30% in Asia, 24% in North America and 23% in Europe, and demand being met mostly by production in the same region (96% of Asian demand, 70 – 75% North American). Growth in production volumes will occur primarily in the same regions as the growth in sales although Asia is also forecast to capture most of the additional volumes from future sales (26% of global sales in 2004; 33% in 2014) and to become a large net exporter of finished cars, compared to its net export of 8 million units in 2007.

Growth in hybrid and electric vehicles will increase the relative importance of embodied emissions

Emissions from global consumption of cars and light commercial vehicles

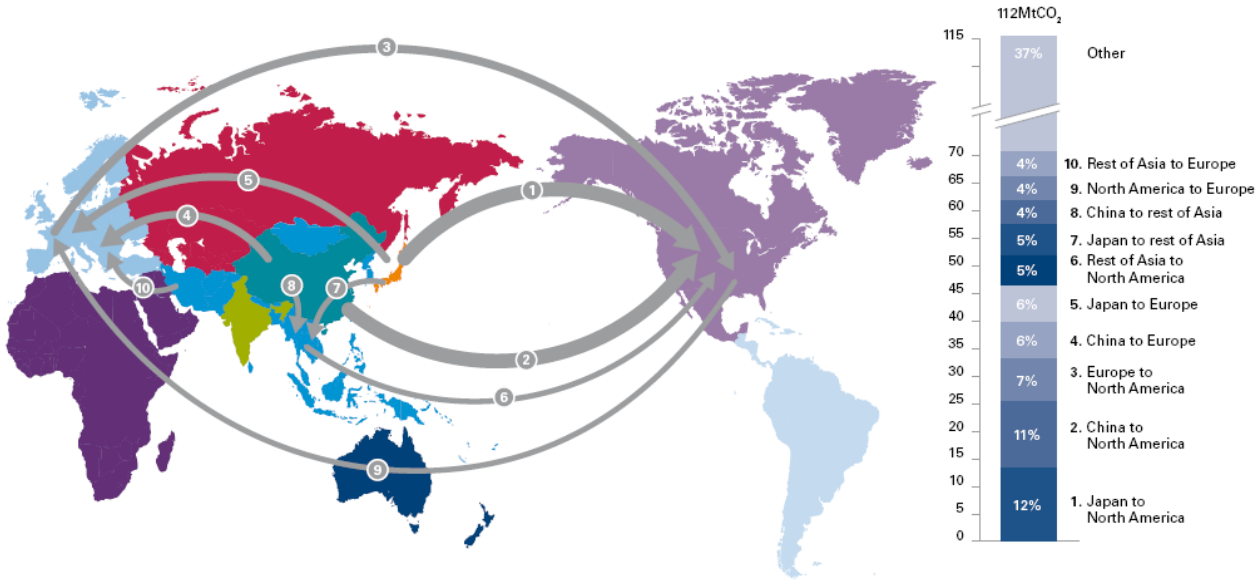


¹ Light commercial vehicles.
² In-use emissions represent annual well-wheel emissions of global fleet .
Note 1: Biofuels penetration assumed to rise gradually to 20% by 2030. It is assumed there is an annual 1% decrease of emissions per car from production/logistics and that hybrids have 20% and plug-in hybrids (PHEVs) and electric vehicles (EVs) have 50% additional embedded emissions over internal combustion engine vehicles.
Source: Global Insight Vehicle Sales Forecast; BCG analysis.

The manufacture of 66 million light duty vehicles each year – the actual level of production in 2008 – causes greenhouse gas emissions of about 0.4GtCO_2e, which is about 1% of global emissions. Using the approximately 700 million vehicles that currently comprise the global car fleet causes a further 1.6GtCO_2e to be emitted. Overall, global automotive consumption causes about 5-6% of global emissions. Over time, increased penetration of hybrid, plug-in hybrid, and electric vehicles will reduce emissions from the use of vehicles, though emissions from the manufacture of cars could increase.

Major flows of embodied emissions in the global auto sector are destined for North America and Europe

Top 10 inter-regional bilateral flows of emissions embodied in motor vehicles and parts

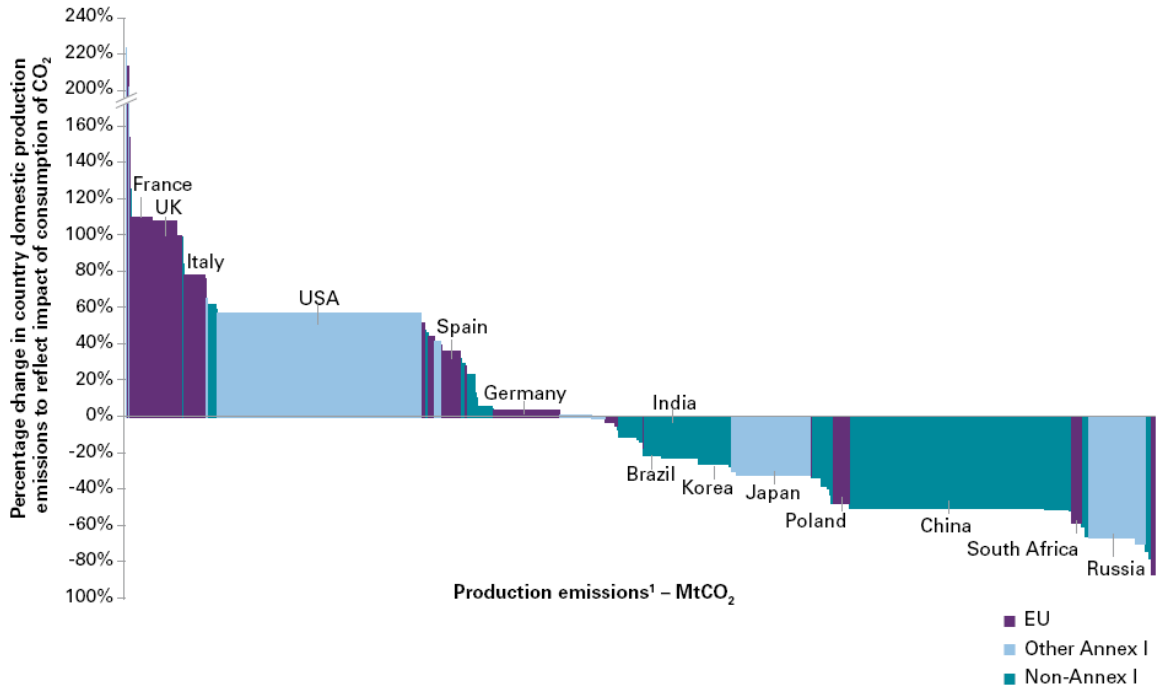


Note 1: Includes Scope 1 emissions (direct), Scope 2 emissions (allocated electricity) and Scope 3 emissions (inputs to automotive manufacture).
Note 2: Includes Scope 1 – Scope 3 emissions generated within the country of automotive production only (ie, excludes flows between countries of inputs to automotive manufacture).
Note 3: Excludes intra-regional flows.
Source: Carbon Trust Analysis; CICERO/SEI/CMU GTAP7 EEBT (2004) model.

The top 10 trade corridors represent over 60% of global inter-regional flows. Flows from Japan and China to North America are the two largest flows and, Europe to North America is the 3rd highest corridor in carbon terms.

Embodied emissions flows drive significant differences between production and consumption views of the auto sector

Percentage change in embodied automotive sector emissions due to imports and exports, by country

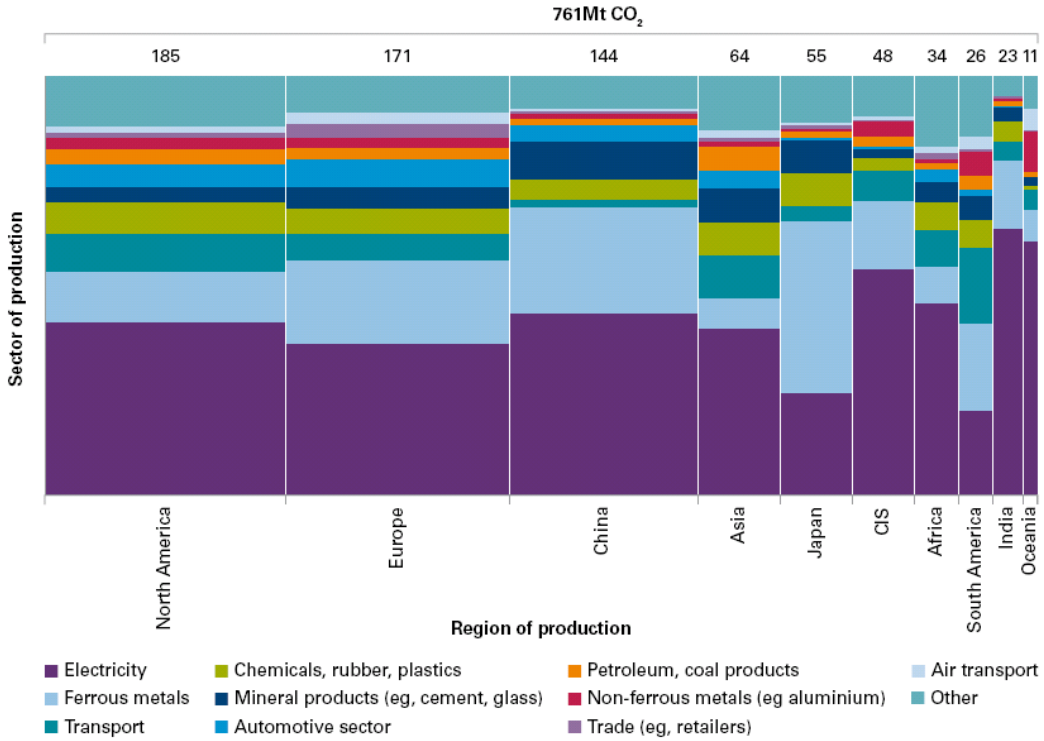


Note 1: Based on all emissions in all sectors generated to satisfy global automotive consumption. Includes Scope 1 (direct), Scope 2 (allocated electricity) and Scope 3 (indirect, supply chain) emissions.
Source: Carbon Trust Analysis; CICERO/SEI/CMU GTAP7 MRIO Model.

The import and export of embodied emissions in automotive supply chains has a significant impact on countries' automotive-related emissions. The international flow of embodied carbon gives rise to an imbalance in the emissions associated with automotive production within a given country. For example, the UK 's consumption of motor vehicles accounts for double its production emissions due to large net imports of embodied emissions.

The purchase of vehicles drives emissions across a wide range of sectors and regions

Emissions generated to satisfy global automotive consumption, split by sector and region (2004)



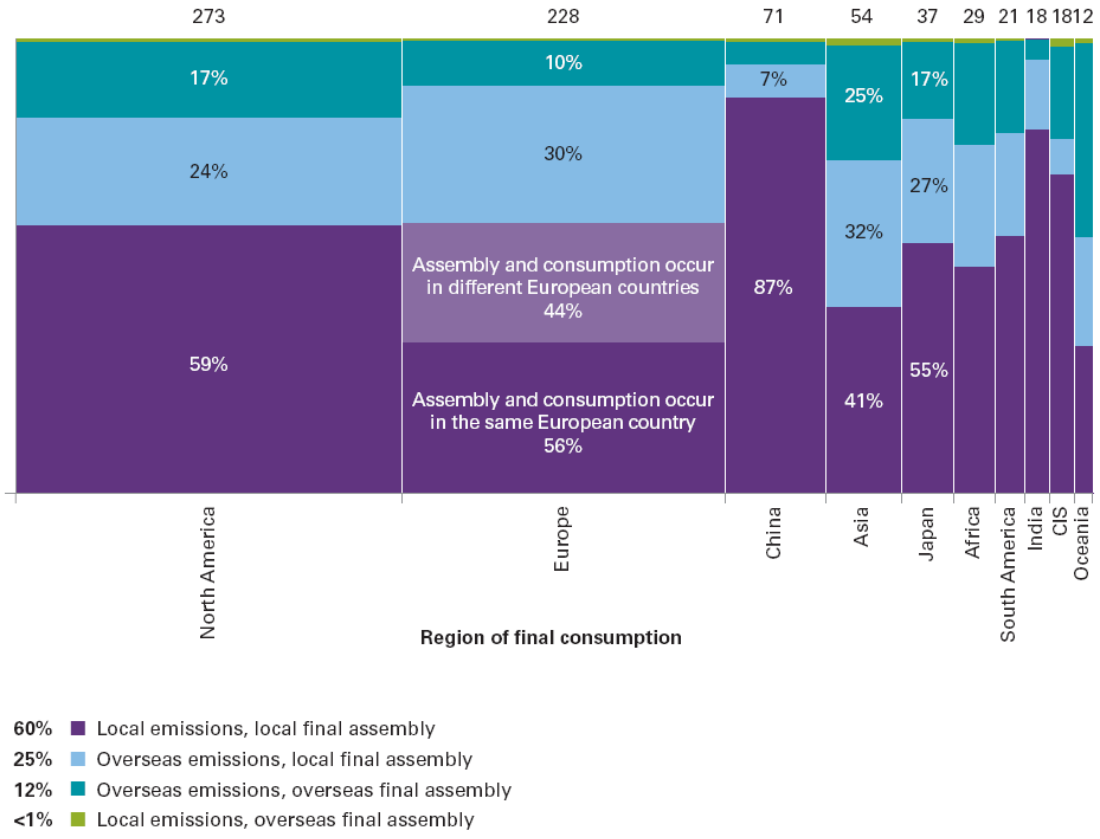
Note 1: Sector direct emissions (eg, heat, transport).
Source: Carbon Trust Analysis; CICERO/SEI/CMU GTAP7 MRIO Model (2004).

Global consumption of motor vehicles in 2004 was the ultimate driver of emissions[1] across a large number of sectors in all regions around the world (embodied emissions only; excludes in-use emissions). The most significant sector of emissions is electricity, followed by ferrous metals, emissions in the transport sector and chemicals, rubber & plastics. The largest single region where emissions are generated is North America, followed by Europe and China.

[1] The global estimate of emissions given here is larger than that shown on page 3. This is due to differing methods of analysis, and differing scope for the sector. The data shown here includes all upstream embodied emissions in the auto supply chain, for all road transport vehicles.

New vehicle sales in North America and Europe drive global embodied emissions in the auto sector

Global consumption of automotive emissions (761MtCO$_2$; excludes in-use emissions), split by region of consumption and by local vs. imported emissions

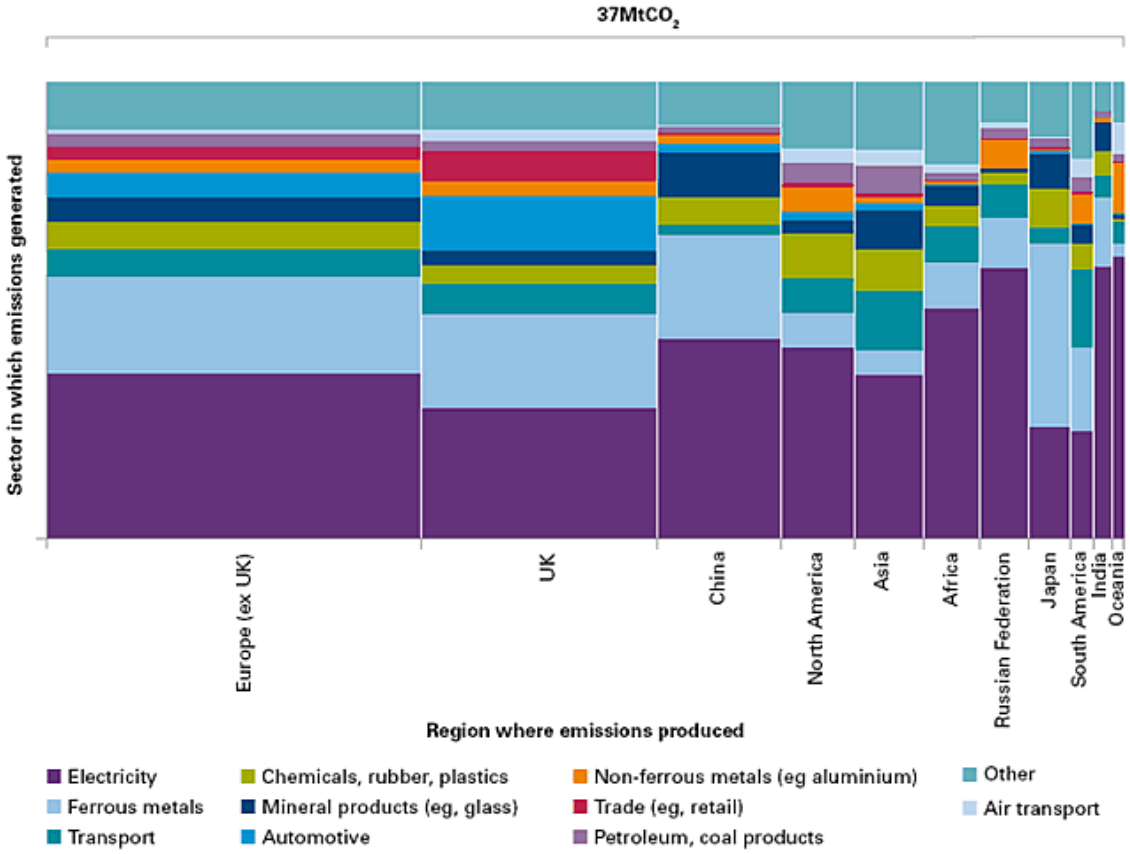


Source: Carbon Trust Analysis; CICERO/SEI/CMU GTAP7 MRIO Model (2004).

The purchase of new vehicles in a particular region drives emissions production both locally and globally. Approximately 60% of embodied emissions associated with the production of motor vehicles and parts are generated in the same region in which they are consumed (i.e., domestic production for domestic consumption). A further 25% of emissions are embodied in components that are subsequently assembled into a car locally, and the remainder (15%) are embodied in cars which are imported from overseas.

Emissions occur globally to satisfy demand for new cars in the UK

Global emissions arising to satisfy UK automotive consumption, split by region and sector of production



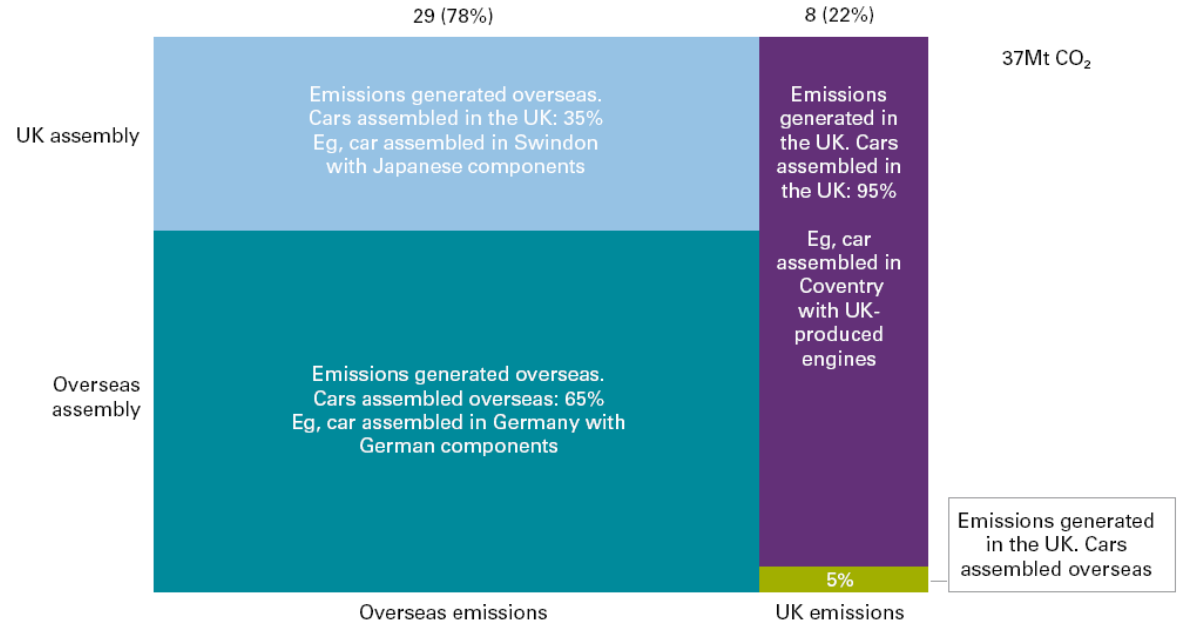
Note 1: Sector direct emissions (heat, transport).
Source: Carbon Trust Analysis; CICERO/SEI/CMU GTAP7 MRIO Model (2004).

The figure above shows the emissions that arise around the world to satisfy UK automotive consumption. European electricity is the single biggest contributor to the UK's 'automotive consumption footprint', but overall UK consumption is satisfied by emissions in many different regions and sectors.

For example, almost 5% of emissions embodied in cars consumed in the UK are generated in the Chinese electricity sector.

Embodied emissions in the auto sector flow between countries in both intermediate and final goods

Emissions generated to satisfy UK automotive consumption, split by geographical source of emissions and final assembly



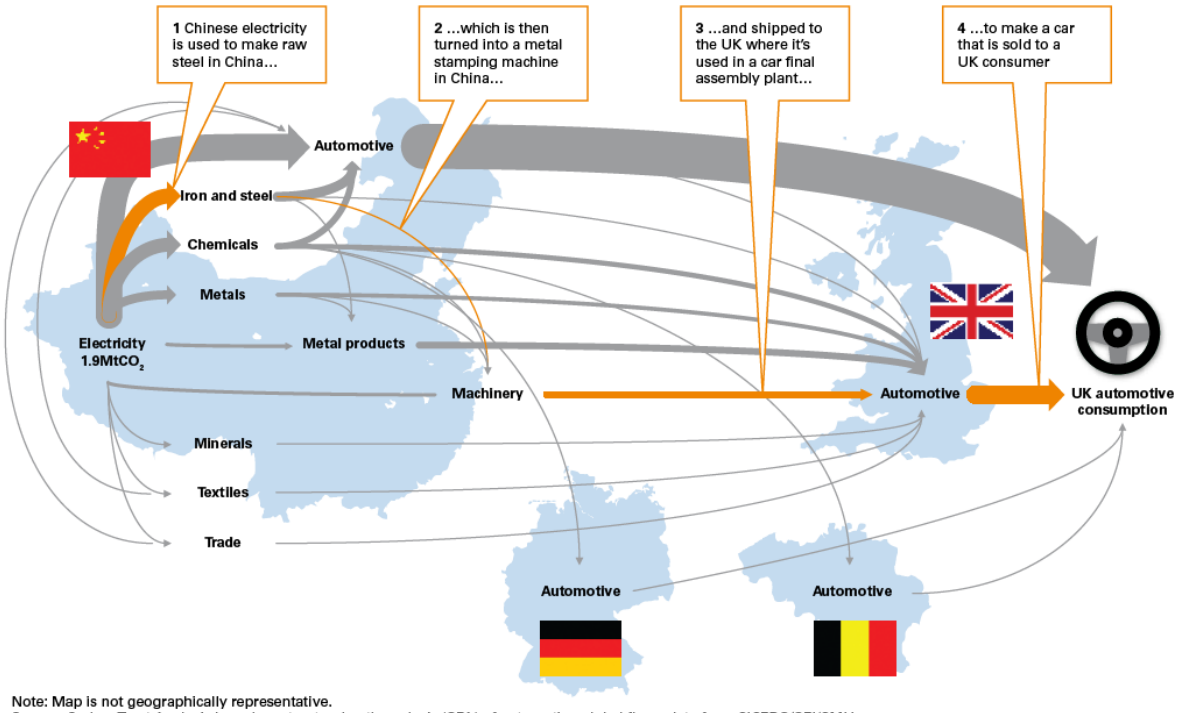
Source: Carbon Trust Analysis; CICERO/SEI/CMU GTAP7 MRIO Model (2004).

As well as being a significant net importer of automotive emissions, the UK exports cars and components (and therefore their embodied carbon emissions) to other countries.

Over 50% of the UK emissions associated with the production of motor vehicles and parts is for export. As the UK's net consumption emissions are double its production emissions in the automotive sector, this implies that of the automotive emissions that the UK consumes, less than 25% are generated domestically. The figure above shows the source of emissions generated to satisfy the UK's net consumption of motor vehicles and parts. In addition to the 22% of domestically produced emissions, 78% of consumption of motor vehicles is satisfied by imports. Of these imported emissions, 35% are embodied in components which undergo final assembly within the UK, and 65% are embodied in imports of finished cars.

Global automotive supply chains drive complex pathways for emissions flows

Pathways of Chinese electricity emissions to UK cars

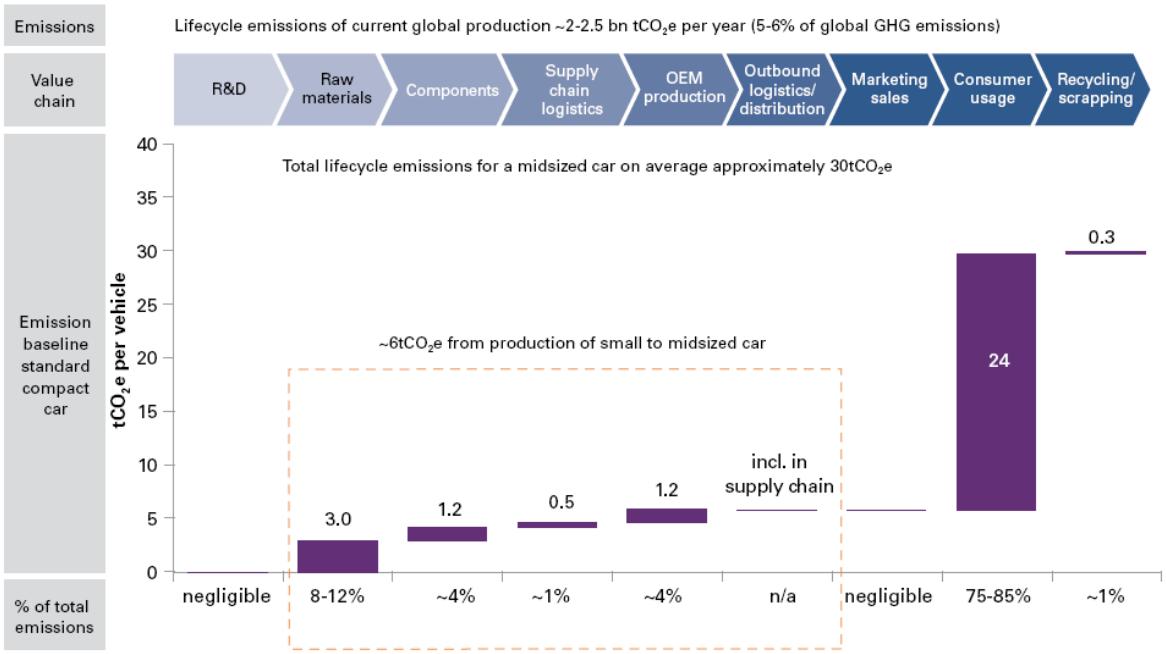


Note: Map is not geographically representative.
Source: Carbon Trust Analysis based on structural path analysis (SPA) of automotive global flows data from CICERO/SEI/CMU.

While some Chinese electricity emissions arising to satisfy UK automotive consumption reach the UK embodied in Chinese automotive components, there are other less direct and less obvious routes. For example, a portion of emissions generated in the Chinese electricity sector is used to make steel in China, which is then turned into a metal stamping machine in China, which is shipped to the UK, where it is used in a UK car final assembly plant to satisfy UK demand for motor vehicles. As well as being a significant importer of automotive emissions, the UK also exports cars and components (and therefore their embodied carbon emissions) to other countries, and over 50% of the UK emissions associated with the production of motor vehicles and parts is for export.

In-use emissions currently dominate the life cycle emissions of cars

Lifecycle emissions from the manufacture and use of a typical car

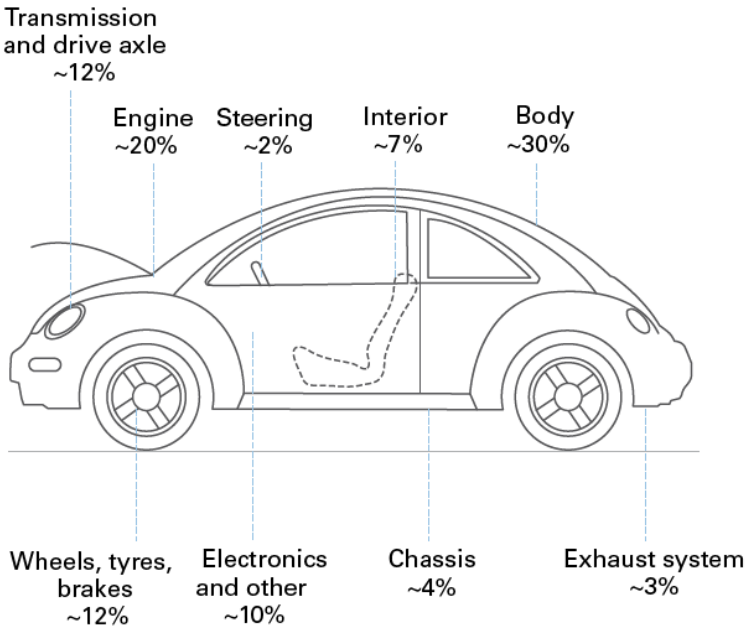


Note 1: Emissions can range significantly depending on size and performance of car, mileage and driving behaviour. Up to ~10t / CO_2 car embedded and 80t CO_2 in-use emissions for large premium vehicles.
Source: Carbon Trust and BCG Analysis based on Life Cycle Analysis publications from several OEM and emissions data from Ricardo.

Each mid-size car sold today is expected to emit 24-36tCO_2e over its lifetime. More than three quarters of these emissions will be from the car itself as it is driven. The remaining 6tCO_2e are emitted during the manufacture of the car, with about 3tCO_2e emitted to make the raw materials such as steel and aluminium. A large premium vehicle can have almost double the manufacturing emissions and four times the tail pipe emissions than an average car.

Embodied emissions are widely distributed across different car components

Distribution of embodied emissions in a typical car by component group

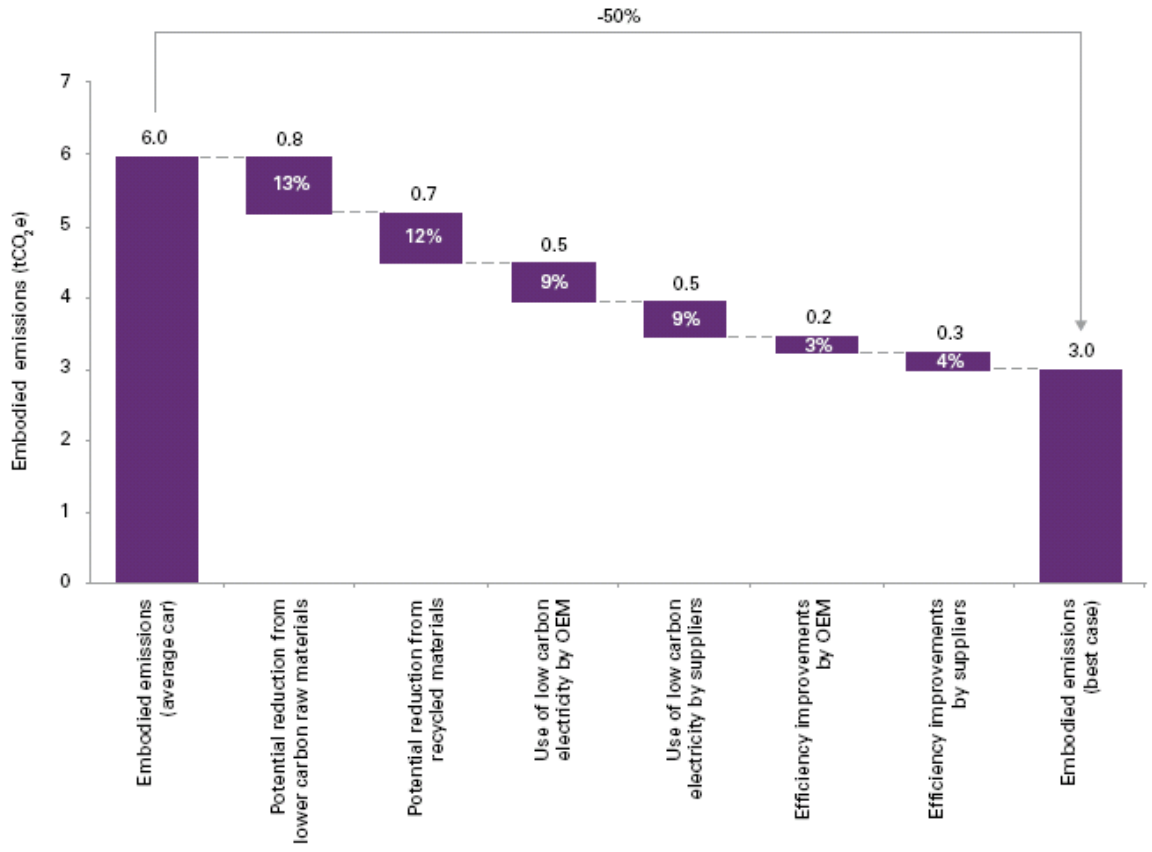


Note: Approximate share or total embodied emissions by vehicle component group based on analysis of emissions embodied in materials
Source: Carbon Trust Analysis; BCG; Ricardo

The greatest proportion of embodied emissions is in the car body, with the engine and transmission and drive axle also being significant contributors. This distribution of emissions in the final product reflects the role of different sectors (see page 6) in contributing to the overall embodied emissions in the automotive sector.

A 50% reduction in embodied emissions is possible through optimising current production processes

Opportunities to reduce embodied emissions in a car

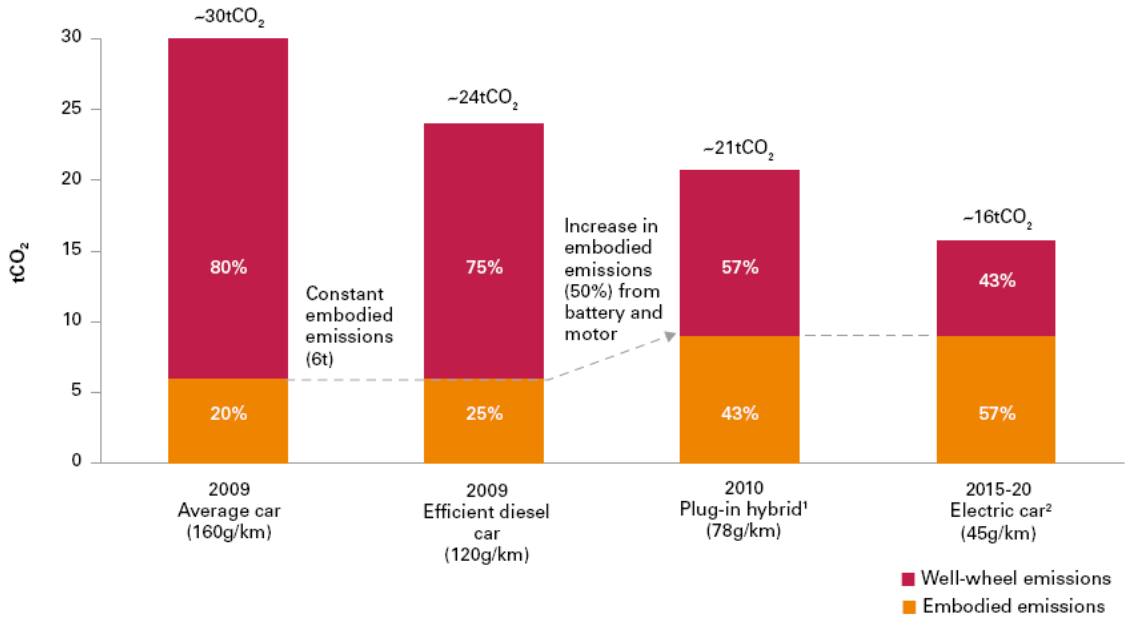


Source: BCG Analysis.

Actions that can reduce the emissions from making cars can be divided into those that involve lowering the emissions involved in creating the raw materials such as steel and aluminium, and those that are involved in transforming the raw materials into a car. The biggest opportunity is with the raw materials, where manufacturers could choose to use recycled material or materials from low carbon suppliers, which could halve the emissions associated with creating raw materials for the car. Car manufacturers may also be able to reduce the total material required through 'smart design' which light-weights the car. Action on production processes would be more diffuse across the final assemblers of cars and their component suppliers and across energy efficiency and sourcing low carbon energy sources. As illustrated in this figure, in combination these actions could potentially halve the embodied emissions per car.

Innovation will be instrumental to delivering major reductions in life cycle emissions of cars

Potential evolution in the relative importance of embodied and in-use automotive emissions



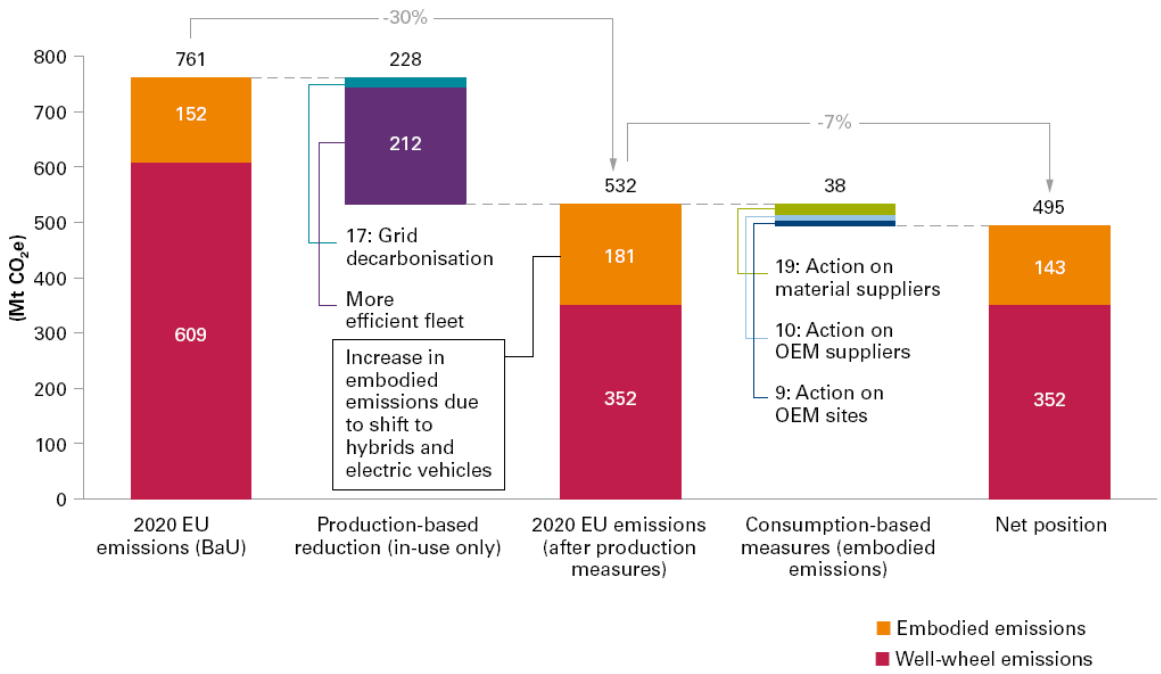
Note 1: Vehicle assumed to drive 150,000km over its lifetime.
¹ Assumes ICE used 50% of the time and generates 89gCO_2/km and electric motor for other 50%. Emissions of electric motor based upon grid factor of 450g/kWh and motor efficiency of 15kWh/100km.
² Emissions of electric motor based upon grid emissions intensity of 300g/kWh and motor efficiency of 15kWh/100km.
Source: Carbon Trust and BCG Analysis based on data from International Energy Agency, Automotive Manufacturers and Ricardo.

For an average car today, around 20% of total vehicle lifecycle emissions arise during production and are embodied in the vehicle, with the remaining 80% generated from the use of the car over its lifetime. However, the contribution of embodied emissions to the total lifecycle emissions of a vehicle is likely to increase as we shift to more efficient diesel cars, hybrids and electric vehicles. This is driven both by an increase in the absolute emissions generated in the production of batteries and lightweight materials required for hybrids and electric vehicles, and a reduction in the use-phase emissions.

By the time electric vehicles are sold more widely in 5-10 years' time, tail-pipe (in-use) emissions could be smaller than the emissions involved in making the car. This will reflect the success in reducing in-use emissions and will require a shift in focus towards emissions embodied in cars. Assuming that the electricity grid is decarbonised, the increase in embodied emissions should not offset the reductions gained from the use-phase, so that on a lifecycle basis emissions per car will decline.

Significant opportunities exist to decarbonise the automotive sector in Europe

Potential reductions in 2020 EU automotive consumption emissions from measures to reduce in-use and embodied emissions



Note 1: New sales emissions only.
Source: Carbon Trust Analysis.

The figure above illustrates the potential scale of emissions savings in 2020 EU automotive consumption emissions resulting from actions to reduce both embodied and in-use emissions. Through more efficient vehicles and electricity grid decarbonisation, total emissions could decrease by about 30%. Reductions in embodied emissions related to lower carbon materials and improved efficiency in automotive manufacturing could reduce emissions another 7%.

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